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THE EFFECTS
OF
SCRAP AUTOMOBILE TIRES
IN WATER

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ABSTRACT

In late spring and summer of 1991 a sixty day environmental impact study was conducted by Deep/Quest 2 Underseas Research Society Inc. on the suitability of scrap automobile tires as an artificial reef construction medium. The study was funded by the Waste Management Branch of the Ontario Ministry of Environment and was performed at Loyalist College, Belleville, Ont. The study was to determine if; a)tires are capable of leaching contaminants into water, b) if chemicals or metals are subject to uptake by fish, and c) if the water used in this study possessed any factors which might be toxic to aquatic organisms. The results of the tests suggest the presence of a factor (or factors) associated with both intact and cut up tires which is acutely toxic to Rainbow Trout (*Salmo gairdneri*) but not to Water Fleas (*Daphnia magna*). The findings of the chemical analysis of water and tissue samples, however, do not reveal the presence of such a factor. Further research is required to identify the nature, source and ultimate environmental impact of this factor.

INTRODUCTION

The idea of using man-made structures to enhance aquatic resources is not a new one. Stone (1985) indicates that artificial reefs have been used in the United States for over 100 years as a technique for improving angling.

Although the majority of the literature pertaining to artificial reefs deals with marine applications, the State of Michigan has been involved in fresh water lake improvement since the early 1930's (Kevern, et. al., 1985). Over the years many materials have been used for artificial reef construction with varying degrees of success. Shipwrecks, logs, rubble, pipe, brush and scrap tires have all been tested with each medium seemingly having strengths and weaknesses depending on the nature of its use.

The use of scrap automobile tires for reef construction, although somewhat controversial, has been one of the most intriguing trends in the field of aquatic resource enhancement. Scrap tire piles have, in the past few years, come to be seen as a potential problem in terms of safe storage and disposal. The very characteristics that make the tires awkward to dispose of (toughness, bulk, etc.) make them interesting candidates for aquatic structures. Over the past 20 years scrap tires have been used with considerable success for a variety of water resource management projects (eg. artificial reefs, floating and submerged breakwaters, erosion control devices).

A study in Florida (Stone, et. al., 1975) demonstrated that tires appear to have no detrimental effects on two species of marine fish maintained in captivity with them. Although the majority of artificial reefs built to date have been marine, there is some precedent for their suitability of use in freshwater applications.

A long term project by Prince, et. al. (1985) in Smith Mountain Lake (Virginia, U.S.A.) showed that after nine years..." the tire structures were, for the most part, in their original locations and showed no signs of deterioration; (b) the tires were still colonized by dense concentrations of fish and periphyton; (c) divers used the reefs extensively and (d) reef fishermen have reduced their efforts for centrarchids, and apparently have switched to striped bass". The study concluded by saying that ... "artificial reefs can be used economically to improve structure-deficient freshwater lentic environments".

Based on these findings, and the lack of relevant data in Canadian freshwater systems, Deep/Quest 2 Underseas Research Society Inc. proposed to the Ontario Ministry of the Environment (O.M.O.E.) to examine and verify the suitability of scrap tires as an artificial reef construction material.

PURPOSE

At the request of the Water Management Branch of the Ontario Ministry of the Environment Deep/Quest 2 Underseas Research Society Inc. proposed to conduct a 60 day laboratory study based at Loyalist College (Belleville, Ontario) to assess the potential environmental impact of scrap automobile tires when used in artificial reefs. After consultation with the O.M.O.E. the impact study was approved with two major objectives.

1) To ascertain if scrap automobile tires, when immersed in freshwater, are liable to leach any potential contaminants into an aquatic system.

2) To determine if the leachates (if they exist) pose any threat, in terms of toxicity, to aquatic organisms.

MATERIALS AND METHODS

Six 450 litre glass aquaria were transported and set up in room L127A (Lennox and Addington Wing) of Loyalist College in early April 1991. The water for the study was drawn f~~or~~rom the Bay of Quinte by Aqua-Blue Water Service (Belleville, Ontario) and transported by water tanker to Loyalist College on April 19, 1991. Approximately 200 litres of extra water was retained on site to replace water drawn for testing.

Since, as described above, the experimental design incorporated two distinct areas of investigation it was necessary to establish two sets of three tanks (under identical conditions).

Leaching and Bio-Accumulation of Tire Products

Three 450 litre aquaria were established with 400 litres of water. Aquarium #1 (A1) contained no tire material and was used as a control. Aquarium #2 (A2) had one intact automobile tire immersed in it. Into aquarium #3 (A3) was placed one tire cut into pieces so as to expose the metallic elements of the tire to the water.

Into each of the three tanks approximately 100 guppies (*Poecilia reticulata*) were introduced as subjects for the bio-accumulation phase of the study. Guppies were originally selected because their availability, small size and hardiness seemed well suited to this type of project. However, after consultation with Mr. Jack Brady of Ortech International (the lab performing the chemical analysis) it became apparent that due to the sample size needed (20-25g) for the fish tissue analysis that a larger uptake subject would be needed. After discussion with Mr. Wolfgang Scheider of Watershed Management Branch, O.M.O.E. goldfish (*Carassius auratus*) were selected and about 75 were added to each of the aquaria.

The aquaria were covered with glass to reduce water loss due to evaporation and water from the reserve supply was added only to maintain the desired water volume. Light for each aquarium was supplied by a 40 watt "cool white" fluorescent tube controlled by a timer to provide 12 hours of light and dark each day. As the room had no windows and the overhead lights were turned off, this was the only source of light for the aquaria. Oxygenation for the aquaria was supplied by a vibrator type air pump, three-way valve and air stones. The fish were fed once a day with a commercial tropical fish diet. In order to reduce the amount of waste in the aquaria the fish were only given enough food to consume in a five to ten minute period.

According to Stone, et. al. (1975) metals, PCB's and hydrocarbon compounds were of particular concern in the tire leaching studies conducted elsewhere. After consultation with the Watershed Management Branch, O.M.O.E. it was decided that water samples be sent to Ortech International Inc. (Mississauga, Ont.) for analysis using: a) Metals Scan, b) PCB/OC's Scan, c) Poly-Aromatic Hydrocarbons (PAH) Scan (for a complete list of the procedures used see Appendix I).

Toxicity to Aquatic Organisms

Three 450 litre aquaria were set up as described above, excepting that fish were not added to the tanks. Water samples from each aquarium (B1- Control, B2- Whole Tire, B3- Cut Tire) were sent to B.A.R. Environmental (Guelph, Ontario) for toxicity testing. As agreed, standard O.M.O.E. testing protocols for Rainbow Trout (*Salmo gairdneri*) and water fleas (*Daphnia magna*) were used. For a description of the methods used see Appendix I.

During the course of the study air and water temperature were recorded daily with pH and dissolved oxygen measured weekly. A record was also made of any goldfish mortality in the aquaria that contained them.

Three litres of water and approximately ten goldfish from each tank (A1, A2, A3) and forty litres of water from each of B1, B2 and B3 were sent by courier on May 7, 1991 for chemical and toxicity testing respectively. These tests were to provide a baseline for the Day 30 and Day 60 tests. Due to delay in obtaining testing equipment at the college, the scrap automobile tires (donated to the project by Belsey Automotive, Picton, Ontario) were not added to the experimental tanks until May 21, 1991 (Day 1). At this point the 60 day impact study began, with water samples being taken on June 19, 1991 (Day 30) and July 19, 1991 (Day 60).

RESULTS AND DISCUSSION

Leaching and Bio-Accumulation of Tire Products

The results of the chemical testing for metals, PCB/OC's and PAH's can be found in tabular form in Appendix II, Tables 1-3. In order to simplify the interpretation of the results, each test will be examined separately.

Metals in Water

There was little significant change in the concentrations of most of the metals tested. Levels of zinc (Zn) fell at Day 30, but rose sharply at Day 60. Although the increase was greatest in the cut tire (A3) sample (3.1 mg/L) it should be noted that levels in the control (A1) rose from less than 0.005mg/L to 0.68mg/L within the same time period indicating that a source of zinc other than tire material must have existed. The most logical candidate for this is the tropical fish diet fed to the goldfish as it was used in all three tanks. Boron (B) levels increased sharply in all three tanks at Day 30 (although were greatest in the experimental tanks) but then fell dramatically back to baseline levels by Day 60. There is no satisfactory explanation for this phenomenon, although the possibility of sample contamination should not be ruled out. Other minor fluctuations in metals do not seem to suggest any significant trends in terms of the leaching of tires.

Metals in Fish Tissue

As with the water samples no real trends could be observed in the results of the fish tissue samples. Certain metals like Aluminium (Al) seemed to decline over the course of the study, while levels of others like Zinc (Zn) fluctuated, both up and down. As before, when changes were observed they were seen in all three tanks, not just the ones with tires.

PCBs/OCs in Water

Results from this series of tests are far more straight forward than those of the metals scan. No detectable amounts of any of the compounds tested for were found in any of the samples.

PCBs/OCs in Fish Tissue

The results of the fish tissue tests are equally clear. With the exception of DDE no detectable amounts of PCBs/OCs could be found in any of the samples sent for analysis. Significant levels of DDE were found in all the baseline (Day 0) samples indicating that many of the goldfish being used in the study were carrying background burdens of the compound. The fish used for this study were obtained (through a local pet store) from a commercial breeder. According to the pet store owner, goldfish are normally raised in large uncovered outdoor ponds, where the chance of encountering contaminants from rain or run off would be quite good.

PAHs in Water

As with the PCBs/OCs no detectable amounts of PAH compounds tested for could be found in any of the water samples, with the exception of Anthracene-d_{10} and Chrysene-d_{12} which were present in all three of the water samples (including the control) on Days 30 and 60. The presence of these two compounds is somewhat mysterious as they occur in the control tank as well as the experimental tanks. Based on this fact one can only speculate that they originate in the fish food or the waste products or even the fish themselves.

PAHs in Fish Tissue

PAH results from the fish tissue samples would seem to support the hypothesis that the levels of Anthracene-d_{10} and Chrysene-d_{12} found in the water samples arose from the fish used in the study. Both compounds were found in all baseline tissue samples and while fluctuating remained present in all the later samples. As a result of this it seems reasonable to label the goldfish themselves as the source of these two poly-aromatic hydrocarbons. The only other finding of note was the presence of Napththalene in all samples taken from the whole tire (A2) tank. As before, since the compound was found in the baseline sample it would seem to preclude the tires as the source.

Toxicity to Aquatic Organisms

As outlined above, two species of aquatic animal were exposed to water from the three tanks in the "B" series of the project. In order to simplify the results each species will be dealt with separately.

Daphnia magna

Day 0

a) Control(B1) - Non lethal.
b) Whole Tire(B2) - Non lethal.
c) Cut Tire(B3) - Non lethal.

Day 30

a)Control(B1) - Non lethal.
b)Whole Tire(B2) - Non lethal.
c)Cut Tire(B3) - Non lethal.

Day 60

a)Control(B1) - Non lethal.
b)Whole Tire(B2) - Non lethal.
c)Cut Tire(B3) - Non lethal.

Salmo gairdneri

Day 0

a)Control(B1) - Non lethal.
b)Whole Tire(B2) - Non lethal.
c)Cut Tire(B3) - Non lethal.

Day 30

a)Control(B1) - Non lethal.
b)Whole Tire(B2) - 100% mortality within 24 hrs.
c)Cut Tire(B3) - 100% mortality within 24 hrs.

Day 60

a)Control(B1) - Non lethal.
b)Whole Tire(B2) - 100% mortality within 24 hrs.
c)Cut Tire(B3) - 100% mortality within 24 hrs.

According to the results obtained from B.A.R. Environmental there would appear to be an agent present in the water samples that is acutely toxic to Rainbow Trout but not to *Daphnia magna*. This finding is all the more surprising due to the fact that mortality among the goldfish used for the bio-accumulation study was very low. The mortality for each aquarium can be seen as a graph in Figure 1. Although there was some initial mortality in all three tanks (due we suspect to transfer stress and a possible fungal outbreak) the number of deaths declines very sharply with time to zero. There seems to be very little difference between the mortality curves of the control versus the experimental tanks.

An examination of the physical data from the study site provides no insight as to the identity of the toxic factor. Air temperature and water temperature were very stable as the heating season was past and the door was kept shut at all times. Both were found to be 22 degrees Celsius (+/- 1 degree) for the duration of the project. Similarly we found no significant changes in pH or dissolved oxygen readings during the course of the study. Values of 7.7 - 7.8 were routinely taken for all tanks during pH measurements. Levels of dissolved oxygen (DO) were found to range from 7.9 - 8.2 mg/L[1] when sampled at the Loyalist College site. At our request they were again taken by B.A.R. before the toxicity tests were begun. The measurements by B.A.R. were consistent with those found at the study site and in the opinion of Keith Holtze (Vice President, Laboratory Services, B.A.R. Environmental) would not have contributed to fish mortality.

Although the toxicity test results would seem to suggest the presence of a factor which is toxic to aquatic vertebrates there is little evidence as to what it might be. The findings of the chemical analysis by Ortech do not seem to point to any compound tested as the source of the toxicity. According to Mr. Jack Brady (Organic Analysis Section, Ortech International) the test results were "quite unremarkable". However, as pointed out by Dr. Gordon Thomas (Manager of Organic Analysis, Ortech International) the PCB/OCs and PAH scans requested by the O.M.O.E. are selective methods used for specific purposes.

Based on these contradictory findings it was decided that the 30 day cut tire(A3) sample and the 60 day whole tire(B2) and cut tire(B3) samples should be re-tested by Ortech using a full scan GC-MSD system capable of analyzing complex unknown mixtures. The GC-Total Ion Current Profile (TIC) (see Appendix III) revealed numerous peaks, which were then compared against the Ortech library database. According to Dr. Thomas, most of the matches are of very poor quality, but do suggest the presence of a number of organic compounds that resemble those which might be found as by-products of the tire manufacturing process, ie. residual monomers and polymers, ingredients from stabilizers and accelerators (eg. sulphur containing compounds like dithiocarbamates, thioureas and benzothiazoles). He also suggested that there may be evidence of the presence of aza-arenes and numerous amine and amide type compounds, as well as phosphoric and pthallic acid plasticizers.

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[1] We had at one point suspected low DO might have caused the mortality in tanks B2 and B3, but investigation revealed that the abnormally low readings (4.5-4.7mg/L) were the result of equipment problems and/or operator error.

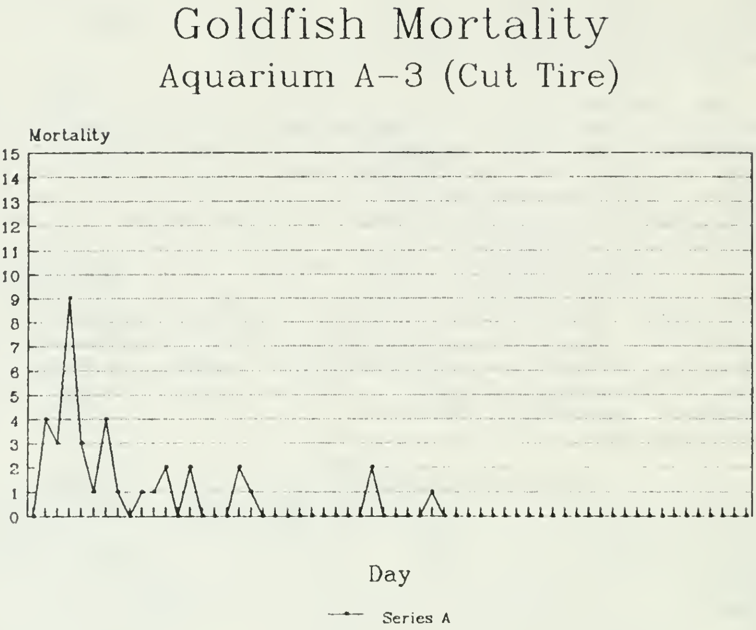

Figure 1c: Mortality of goldfish exposed to a single cut-up automobile tire during 60-day impact study.

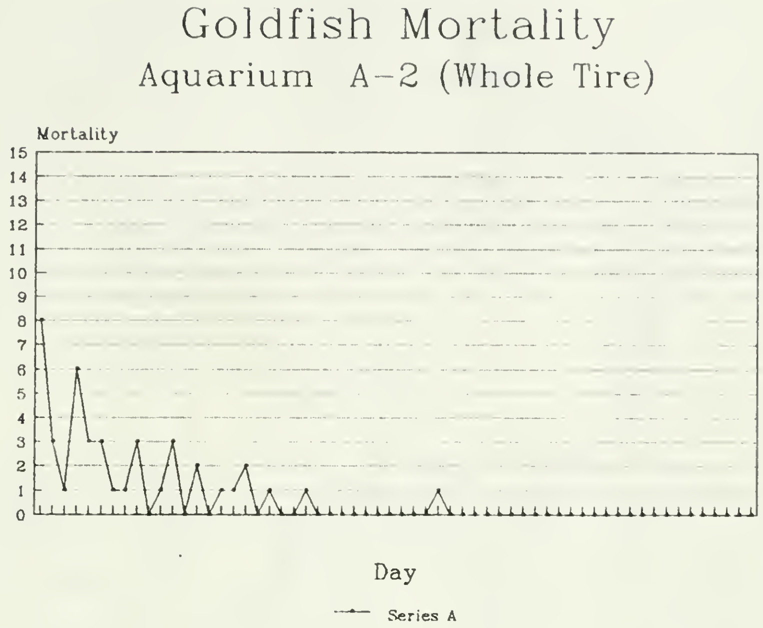

Figure 1b: Mortality of goldfish exposed to a single intact automobile tire during 60-day impact study.

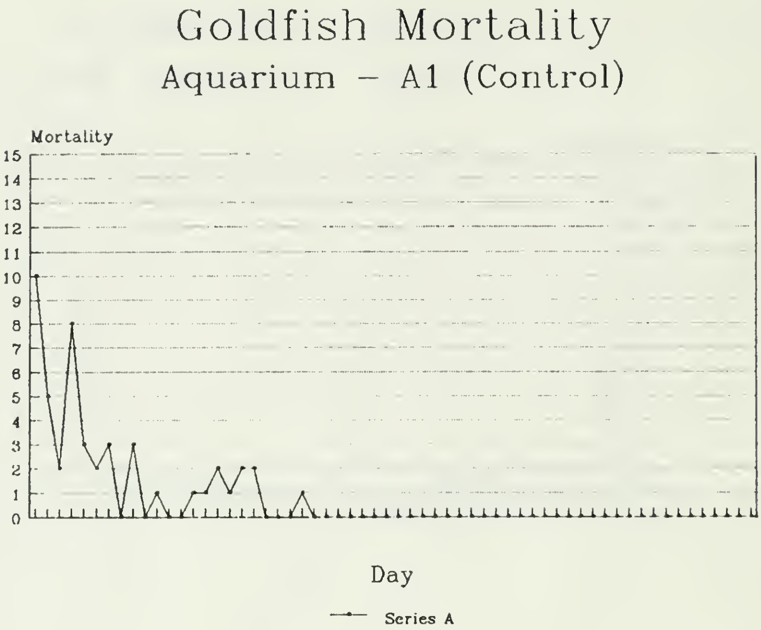

Figure 1a: Mortality of goldfish exposed to no tire material (control) during 60-day impact study.

As a cross-check, a 40 litre sample of water from each of chemical analysis tanks A2 and A3 was sent on day 64 to B.A.R. for comparison of their toxic effects on trout to those of B2 and B3. The sample from A2 and A3 proved to be equally toxic (100% mortality within 24 hrs) to Rainbow Trout. These results came as a great surprise since the guppies and goldfish survived in that water for well over 75 days with only minimal mortality. It is fairly well known fact (at least among aquarists) that the guppy and goldfish families (Cyprinidontae and Cyprinidae, respectively) are generally more tolerant to adverse environmental conditions than the trout (Salmonidae) family. Whether this inherent hardiness played a part in the low mortality of the uptake subjects remains, at this point, unclear.

CONCLUSIONS

The results of this study indicate that there may exist a factor associated with scrap automobile tires which is acutely toxic to rainbow trout (at least under *in vitro* conditions). Due to the type of the chemical analysis performed the exact nature of what this factor might be remains unknown. The chemical tests, as performed, suggest that tires appear to leach very little in the way of metals, PCBs and PAHs into fresh water when immersed for relatively short (60 days) periods. Similarly the results of the uptake phase of the study show no significant bio-accumulation of any of the elements or compounds tested for.

There are several questions, however, that are posed by this study and their solution should be incorporated into any future studies.

1) What is the exact nature of the toxic factor and what is its source?

2) Is the source of the toxicity directly associated with automobile tires (ie. in the tires) or could it be an external contaminant (oil, gas, etc.) which might be removed?

3) Is the toxic factor stable and persistent or does it breakdown and/or decline over time?

4) Did the relatively high volume of tire material to water (1 tire/400 litres of water) contribute to the effect?

5) Can the same phenomena be observed in an field study situation? Water samples taken from the immediate vicinity well established tire structure (eg. a floating tire break

water that is several years old) could be compared to those from a newly installed structure.

There is clearly strong need for continuing research into this issue. The problem of the disposal of the millions of scrap automobile tires generated every year will dictate that many potential disposal schemes will be considered and tested. It is of paramount importance that the environmental safety and stability of tires be established once and for all. The ramifications of not doing so (both in terms of future projects and the dismantling of existing ones) are dire.

It is the recommendation of the Deep/Quest 2 Underseas Research Society Inc. that further investigation on the suitability of scrap automobile tires for artificial reef building be carried out, both in the laboratory and in the field. The widespread interest that this preliminary study has generated clearly shows the validity in pursuing this important topic of research.

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APPENDIX I (a)

Organic Compounds Selected for Testing by O.M.O.E. for Deep/Quest 2 Tire Leaching Study

PCB
HCB
Heptachlor
Aldrin
DDE
Mirex
α-HCH
β-HCH
γ-HCH
α-Chlordane
γ-Chlordane
o,p,-DDT
p,p,-DDD
p,p,-DDT
Toxaphene
OCS
HCBD
1,3,5-CB
1,2,4-CB
1,2,3-CB
HCE
2,4,5-TCT
2,3,6-TCT
1,2,4,5-CB
1,2,3,5-CB
1,2,3,4-CB
Penta-CB

Napththalene
Acenaphthene
Fluorene
Phenanthrene
Anthracene
Fluoranthene
Pyrene
Benz[a]Anthracene
Chrysene
Benz[b]Fluoranthene
Benz[k]Fluoranthene
Benz[a]Pyrene
Indeno[123-cd]Pyrene
Dibenz[ah]Anthracene
Benz[ghi]Perylene

APPENDIX I (b)

Procedures used by Ortech International for the chemical analysis of the Deep/Quest 2 tire leaching samples.

Metals Procedures

WATER

Multielement - An aliquot of sample was digested with nitric acid. The resulting solution was diluted to volume for analysis by DC plasma emission spectrophotometry and/or flame atomic absorption spectrophotometry.

Arsenic, Selenium and Antimony - An aliquot of sample was digested with sulfuric and nitric acids to fumes of SO_3. The resulting solution was diluted to volume with 20% hydrochloric acid and analyzed by hydride generation atomic absorption spectrophotometry using sodium borohydride as the reductant.

Mercury - An aliquot of sample was (10 mL) was treated with nitric/sulphuric acid (1:1) mixture (1.5 mL), potassium permanganate (1.5 mL) and potassium persulphate (1 mL) and allowed to stand overnight. The resulting solution was reduced with hydroxylamine hydrochloride (1 mL) and heated for 30 minutes at 90 C. This solution was analyzed by an automated cold vapour atomic absorption spectrophotometry method using a solution of stannous chloride (25%) in hydrochloric acid (20%) as the reductant.

FISH

Multielement - An accurately weighed portion of the sample was digested in concentrated nitric and sulfuric acids. The solution was made to volume and analyzed by DC plasma emission spectrophotometry and flame absorption spectrophotometry.

Arsenic, Selenium and Antimony - An aliquot of the digested sample was redigested in nitric, sulfuric and perchloric acids to fumes of SO_3. The resulting solution was diluted with 20% hydrochloric acid and analyzed by hydride generation atomic absorption spectrophotometry using sodium borohydride as a reductant.

Mercury - An aliquot (approximately 0.5g) of each sample was digested with sulfuric and nitric acids at 60 C until dissolution was complete. The oxidation of organic was completed by the addition of potassium permanganate solution. Excess permanganate was reduced by addition of hydroxylamine hydrochloride and the solution was diluted to volume. The solution was further reduced with stannous chloride immediately before analysis by cold vapour atomic absorption spectrophotometry.

PCB/OC Procedures

WATER

Approximately 1L of sample was triple extracted with methylene chloride, cleaned up on 2% water deactivated Florisil and analyzed by dual capillary GC/EC.

FISH

Approximately 5g homogenate (accurately weighed) is acid digested with concentration HCL, double extracted with 25% methylene chloride in hexane. The pooled extracts are neutralized with $NaHCO_3$ and an aliquot is analyzed for PCBs/OCs using the above Florisil cleanup/separation and dual capillary GC/EC.

PAH Procedures

WATER

Sample was pH adjusted to <2 with 50% H_2SO_4. Separatory funnel extraction was then conducted using CH_2Cl_2 (3 x 75 mL). The extract was dried (Na_2SO_4), concentrated in a Kuderna/Danish evaporator to 1 mL. An aliquot was injected into a GC-MSD for identification and measurement.

FISH

An accurately weighed fish homogenate aliquot (2.5g) is acid digested (concentration HCL) for 10 hours. The sample is then extracted with 15% dichloromethane/hexane (x2); the extract is neutralized ($NaHCO_3$), filtered and concentrated (vortex evaporator). The extract is then cleaned up using gel permeation chromatography (GPC) and the PAH fraction collected, concentrated (vortex evaporator) prior to GC-MSD identification and measurement.

APPENDIX I (c)

Procedures used by B.A.R. Environmental for toxicity testing of Deep/Quest 2 tire leaching samples.

Two 20 L pails of water from each of tanks B1, B2 and B3 were sent via courier on the specified sample dates. The water from the two pails was mixed together prior to testing to provide one combined 40 L sample for each tank. Dissolved oxygen and pH levels were tested by B.A.R. before testing to ensure that the samples were within acceptable levels.

For each rainbow trout test, twenty fish (two replicates with ten fish per replicate) were exposed to the undiluted sample for a maximum of 96 hours. For *Daphnia magna*, five sample concentrations ranging from 100% (undiluted sample) to 6% (diluted with distilled water) and a control were tested for a maximum of 48 hours. Each concentration consisted of eight replicates with three animals per replicate. A mortality rate of less than 10% was considered to be " non lethal" under the parameters of the study, ie. O.M.O.E. toxicity testing protocols.

APPENDIX II

Chemical Analysis Data as prepared by Ortech International for Deep/Quest 2 Tire Leaching Study

The format for the data presented in the following tables is as follows. Each set of tables represents the results for the Day 0, Day 30, and Day 60 samples respectively. Sample # A1 refers to the Control (no tire material)tank, Sample # A2 to the intact tire tank and sample # A3 to the cut tire tank.

Table 1

Metals Results - Water
Concentration mg/L

Element	#A1 01A	#A2 02A	#A3 03A
Al	<0.05	<0.05	<0.05
B	<0.07	<0.07	<0.07
Be	0.0006	0.0003	<0.0002
Ca	39	40	42
Cd	<0.002	<0.002	<0.002
Co	<0.02	<0.02	<0.02
Cr	<0.01	<0.01	<0.01
Cu	<0.01	<0.01	<0.01
Fe	0.03	<0.02	0.03
Mg	3.5	3.6	3.6
Mn	<0.003	<0.003	<0.003
Mo	<0.004	<0.004	<0.004
Na	5.7	5.9	6.0
Ni	<0.01	<0.01	<0.01
P	<2	<2	<2
Pb	<0.03	<0.03	<0.03
Si	1.6	1.5	1.7
V	<0.01	<0.01	<0.01
Zn	<0.01	<0.01	0.04
Ti	<0.004	<0.004	<0.004
Sn	<0.02	<0.02	<0.02
Tl	<0.02	<0.02	<0.02
Ba	0.049	0.035	0.035
K	<1	<1	<1
As	<0.001	<0.001	<0.001
Se	<0.0005	<0.0005	<0.0005
Sb	<0.0005	<0.0005	<0.0005
Hg	<0.0001	<0.0001	<0.0001

Table 1

Metals Results - Water
Concentration mg/L

Element	#A1 91-42-A0741 1A	#A2 91-42-A0741 2A	#A3 91-42-A074 3A
Al	<0.05	<0.05	<0.05
B	0.48	0.94	1.42
Be	<0.0002	<0.0002	<0.0002
Ca	28	33	30
Cd	<0.005	<0.005	<0.005
Co	<0.02	<0.02	<0.02
Cr	<0.01	<0.01	<0.01
Cu	<0.01	<0.01	<0.01
Fe	<0.02	<0.02	<0.02
Mg	2.38	2.45	4.1
Mn	<0.003	<0.003	<0.003
Mo	0.017	<0.004	<0.004
Na	11.8	12.4	10
Ni	<0.01	<0.01	<0.01
P	1.0	0.93	0.15
Pb	<0.05	<0.05	<0.05
Si	5.6	13	8.1
V	0.07	0.07	0.06
Zn	<0.005	<0.005	<0.005
K	3.8	4.1	3.1
Ti	<0.004	<0.004	<0.004
Ba	0.021	0.050	0.047
Sn	<0.02	<0.02	<0.02
Tl	0.31	0.27	0.23
As	<0.001	<0.001	<0.001
Se	<0.0005	<0.0005	<0.0005
Sb	<0.0005	0.0008	0.0006
Hg	<0.0001	<0.0001	<0.0001

Table 1

Metals Results - Water
Concentration mg/L

Element	# A1 91-42-A0916 1A	# A2 91-42-A0916 2A	# A3 91-42-A0916 3A
Al	<0.05	<0.05	<0.05
B	<0.07	<0.07	<0.07
Be	<0.0002	<0.0002	<0.0002
Ca	41	42	44
Cd*	<0.005	<0.005	<0.005
Co	<0.02	<0.02	<0.02
Cr	<0.01	<0.01	<0.01
Cu	<0.01	<0.01	<0.01
Fe	<0.02	<0.02	<0.02
Mg	4.3	4.2	4.1
Mn	<0.003	<0.003	<0.003
Mo	<0.004	<0.004	<0.004
Na	7.6	8.4	7.6
Ni	<0.01	<0.01	<0.01
P	1.5	1.6	0.56
Pb*	<0.05	<0.05	<0.05
Si	<0.02	<0.02	1.3
V	<0.01	<0.01	<0.01
Zn*	0.68	2.3	3.1
K	2.9	2.6	2.3
Ti	<0.004	<0.004	<0.004
Ba	0.025	0.048	0.041
Sn	<0.02	<0.02	<0.02
Tl	<0.02	<0.02	<0.02
As	<0.001	<0.001	<0.001
Se	<0.0005	<0.0005	<0.0005
Sb	<0.0005	<0.0005	<0.0005
Hg	<0.0001	<0.0001	<0.0001

*Confirmed by FAA.

Table 1A

Metals Results - Fish
Concentration µg/g

Element	#A1 01D	#A2 02D	#A3 03D
Al	54	60	48
B	<3	<3	<3
Be	0.20	0.19	0.18
Ca	5400	11900	8100
Cd	<0.3	<0.3	<0.3
Co	<1	<1	<1
Cr	0.98	1.18	<0.5
Cu	1.3	1.8	1.5
Fe	87	98	86
Mg	150	300	220
Mn	5.7	8.5	7.0
Mo	<0.2	<0.2	<0.2
Na	810	970	940
Ni	<0.5	<0.5	<0.5
P	4800	8600	6700
Pb	<2.5	<2.5	<2.5
Si	<1	23	16
V	1.4	2.2	1.7
Zn	<0.25	<0.25	<0.25
K	1400	1600	1500
Ti	3.7	3.2	2.8
Ba	11.0	12.5	7.00
Sn	<1	<1	<1
Tl	5.1	9.7	6.8
As	<0.5	<0.5	<0.5
Se	<0.25	<0.25	<0.25
Sb	<0.25	<0.25	<0.25
Hg	<0.02	<0.02	<0.02

Table 1A

Metals Results - Fish
Concentration µg/g

Element	#A1 91-42-A0741 1A	#A2 91-42-A0741 2A	#A3 91-42-A074 3A
Al	9.5	4.9	18
B	<3	<3	<3
Be	<0.2	<0.2	<0.2
Ca	10400	22200	12100
Cd	<0.3	<0.3	<0.3
Co	<1	<1	<1
Cr	1.9	3.0	1.6
Cu	1.3	1.4	1.4
Fe	35	37	88
Mg	240	420	280
Mn	5.7	9.7	13
Mo	<0.2	<0.2	<0.2
Na	1260	1400	1240
Ni	0.83	1.1	1.0
P	8300	16800	9500
Pb	<2.5	<2.5	<2.5
Si	3.9	2.9	1.4
V	<0.25	1.5	0.99
Zn	88	120	100
K	1600	2100	2100
Ti	<0.20	<0.20	<0.20
Ba	6.51	16.8	7.22
Sn	<1	<1	<1
Tl	<1	<1	<1
As	<0.50	<0.50	<0.50
Se	<0.25	<0.25	<0.25
Sb	<0.25	<0.25	<0.25
Hg	<0.02	<0.02	<0.02

Table 1A

Metals Results - Fish
Concentration mg/kg

Element	# A1 91-42-A0916 1D	# A2 91-42-A0916 2D	# A3 91-42-A0916 3D
Al	8.8	3.8	4.3
B	<3.5	<3.5	<3.5
Be	0.08	0.07	0.15
Ca	7500	7600	8800
Cd	<0.25	<0.25	<0.25
Co	<0.50	<0.5	<0.5
Cr	1.1	1.4	1.2
Cu	0.71	1.2	1.0
Fe	26	24	63
Mg	210	230	240
Mn	3.5	5.2	7.4
Mo	<0.2	<0.20	<0.20
Na	1000	1100	1100
Ni	<0.5	0.33	<0.5
P	9300	10200	11700
Pb	<2.5	<2.5	<2.5
Si	6.5	4.7	3.0
V	0.99	0.95	1.5
Zn	40	81	120
K	1800	1900	2200
Ti	<0.2	<0.2	0.50
Ba	5.7	5.1	4.6
Sn	<1	<1	<1
Tl	38	40	43
As	<0.125	<0.125	<0.125
Se	<0.063	<0.063	<0.063
Sb	<0.063	<0.063	<0.063
Hg	0.027	0.027	0.027

Table 2
PCBs/OCs Results - Water
Concentration μg/L (ppb)

Compounds	MDL*	#A1 91-42-A 493-01B	#A2 91-42-A 493-02B	#A3 91-42-A 493-03B
PCB	0.10	**ND	ND	ND
HCB	0.01	ND	ND	ND
Heptachlor	0.01	ND	ND	ND
Aldrin	0.02	ND	ND	ND
DDE	0.01	ND	ND	ND
Mirex	0.01	ND	ND	ND
α-HCH	0.02	ND	ND	ND
β-HCH	0.02	ND	ND	ND
γ-HCH	0.02	ND	ND	ND
α-Chlordane	0.01	ND	ND	ND
γ-Chlordane	0.01	ND	ND	ND
o,p-DDT	0.01	ND	ND	ND
p,p-DDD	0.01	ND	ND	ND
p,p-DDT	0.01	ND	ND	ND
Toxaphene	0.20	ND	ND	ND
OCS	0.01	ND	ND	ND
HCBD	0.01	ND	ND	ND
1,3,5-CB	0.01	ND	ND	ND
1,2,4-CB	0.01	ND	ND	ND
1,2,3-CB	0.01	ND	ND	ND
HCE	0.01	ND	ND	ND
2,4,5-TCT	0.01	ND	ND	ND
2,3,6-TCT	0.01	ND	ND	ND
1,2,4,5-CB	0.01	ND	ND	ND
1,2,3,5-CB	0.01	ND	ND	ND
1,2,3,4-CB	0.01	ND	ND	ND
Penta-CB	0.01	ND	ND	ND

* MDL = Method Detection Level

**ND = none detected = <MDL

Table 2
PCBs/OCs Results - Water
Concentration µg/L (ppb)

Compounds	MDL*	#A1 91-42-A 741-01B	#A2 91-42-A 741-02B	#A3 91-42-A 741-03B
PCB	0.10	**ND	ND	ND
HCB	0.01	ND	ND	ND
Heptachlor	0.01	ND	ND	ND
Aldrin	0.02	ND	ND	ND
DDE	0.01	ND	ND	ND
Mirex	0.01	ND	ND	ND
α-HCH	0.02	ND	ND	ND
β-HCH	0.02	ND	ND	ND
γ-HCH	0.02	ND	ND	ND
α-Chlordane	0.01	ND	ND	ND
γ-Chlordane	0.01	ND	ND	ND
o,p-DDT	0.01	ND	ND	ND
p,p-DDD	0.01	ND	ND	ND
p,p-DDT	0.01	ND	ND	ND
Toxaphene	0.20	ND	ND	ND
OCS	0.01	ND	ND	ND
HCBD	0.01	ND	ND	ND
1,3,5-CB	0.01	ND	ND	ND
1,2,4-CB	0.01	ND	ND	ND
1,2,3-CB	0.01	ND	ND	ND
HCE	0.01	ND	ND	ND
2,4,5-TCT	0.01	ND	ND	ND
2,3,6-TCT	0.01	ND	ND	ND
1,2,4,5-CB	0.01	ND	ND	ND
1,2,3,5-CB	0.01	ND	ND	ND
1,2,3,4-CB	0.01	ND	ND	ND
Penta-CB	0.01	ND	ND	ND

* MDL = Method Detection Level

**ND = none detected = <MDL

Table 2
Organochlorine Residues in water samples
(ppb)

Compounds	Detection Limit	#A1 91-42-A 0916-01C	#A2 91-42-A 0916-02C	#A3 91-42-A 0916-03C
PCB	0.10	*ND	ND	ND
HCB	0.01	ND	ND	ND
Heptachlor	0.01	ND	ND	ND
Aldrin	0.02	ND	ND	ND
DDE	0.01	ND	ND	ND
Mirex	0.01	ND	ND	ND
α-HCH	0.02	ND	ND	ND
β-HCH	0.02	ND	ND	ND
γ-HCH	0.02	ND	ND	ND
α-Chlordane	0.01	ND	ND	ND
γ-Chlordane	0.01	ND	ND	ND
o,p-DDT	0.01	ND	ND	ND
p,p-DDD	0.01	ND	ND	ND
p,p-DDT	0.01	ND	ND	ND
Toxaphene	0.20	ND	ND	ND
OCS	0.01	ND	ND	ND
HCBD	0.01	ND	ND	ND
1,3,5-CB	0.01	ND	ND	ND
1,2,4-CB	0.01	ND	ND	ND
1,2,3-CB	0.01	ND	ND	ND
HCE	0.01	ND	ND	ND
2,4,5-TCT	0.01	ND	ND	ND
2,3,6-TCT	0.01	ND	ND	ND
1,2,4,5-CB	0.01	ND	ND	ND
1,2,3,5-CB	0.01	ND	ND	ND
1,2,3,4-CB	0.01	ND	ND	ND
Penta-CB	0.01	ND	ND	ND

*ND = none detected = < the detection limits shown.

Table 2A
PCB/OC Results - Fish
Concentration ng/gm (ppb)

Compounds	MDL*	#A1 91-42-A 741-01D	#A2 91-42-A 741-02D	#A3 91-42-A 741-03D
PCB	20	**ND	ND	ND
HCB	1	ND	ND	ND
Heptachlor	1	ND	ND	ND
Aldrin	1	ND	ND	ND
DDE	1	ND	1.2	ND
Mirex	5	ND	ND	ND
α-HCH	1	ND	ND	ND
β-HCH	1	ND	ND	ND
γ-HCH	1	ND	ND	ND
α-Chlordane	2	ND	ND	ND
γ-Chlordane	2	ND	ND	ND
o,p-DDT	5	ND	ND	ND
p,p-DDD	5	ND	ND	ND
p,p-DDT	5	ND	ND	ND
OCS	1	ND	ND	ND
Toxaphene	200	ND	ND	ND
HCBD	1	ND	ND	ND
1,3,5-CB	2	ND	ND	ND
1,2,4-CB	2	ND	ND	ND
1,2,3-CB	2	ND	ND	ND
HCE	1	ND	ND	ND
2,4,5-TCT	1	ND	ND	ND
2,3,6-TCT	1	ND	ND	ND
1,2,4,5-CB	1	ND	ND	ND
1,2,3,5-CB	1	ND	ND	ND
1,2,3,4-CB	1	ND	ND	ND
Penta-CB	1	ND	ND	ND
Lipids (%)	-	0.44	0.33	0.50

* MDL = Method Detection Level

**ND = none detected = <MDL

Table 2A
PCB/OC Results - Fish
Concentration ng/gm (ppb)

Compounds	MDL*	#A1 91-42-A 493-01D	#A2 91-42-A 493-02D	#A3 91-42-A 493-03D
PCB	20	**ND	ND	ND
HCB	1	ND	ND	ND
Heptachlor	1	ND	ND	ND
Aldrin	1	ND	ND	ND
DDE	1	3.0	1.7	1.9
Mirex	5	ND	ND	ND
α-HCH	1	ND	ND	ND
β-HCH	1	ND	ND	ND
γ-HCH	1	ND	ND	ND
α-Chlordane	2	ND	ND	ND
γ-Chlordane	2	ND	ND	ND
o,p-DDT	5	ND	ND	ND
p,p-DDD	5	ND	ND	ND
p,p-DDT	5	ND	ND	ND
OCS	1	ND	ND	ND
Toxaphene	200	ND	ND	ND
HCBD	1	ND	ND	ND
1,3,5-CB	2	ND	ND	ND
1,2,4-CB	2	ND	ND	ND
1,2,3-CB	2	ND	ND	ND
HCE	1	ND	ND	ND
2,4,5-TCT	1	ND	ND	ND
2,3,6-TCT	1	5.6	ND	ND
1,2,4,5-CB	1	ND	ND	ND
1,2,3,5-CB	1	ND	ND	ND
1,2,3,4-CB	1	ND	ND	ND
Penta-CB	1	ND	ND	ND
Lipids (%)	-	0.86	0.78	0.73

* MDL = Method Detection Level

**ND = none detected = <MDL

Table 2A
Organochlorine Residues in fish samples
(ppb)

Compounds	Detection Limit	#A1 91-42-A 0916-01D	#A2 91-42-A 0916-02D	#A3 91-42-A 0916-03D
PCB	20	*ND	ND	ND
HCB	1	ND	ND	ND
Heptachlor	1	ND	ND	ND
Aldrin	1	ND	ND	ND
DDE	1	1.94	ND	2.03
Mirex	5	ND	ND	ND
α-HCH	1	ND	ND	ND
β-HCH	1	ND	ND	ND
γ-HCH	1	ND	ND	ND
α-Chlordane	2	ND	ND	ND
γ-Chlordane	2	ND	ND	ND
o,p-DDT	5	ND	ND	ND
p,p-DDD	5	ND	ND	ND
p,p-DDT	5	ND	ND	ND
OCS	1	ND	ND	ND
Toxaphene	200	ND	ND	ND
HCBD	1	ND	ND	ND
1,3,5-CB	2	ND	ND	ND
1,2,4-CB	2	ND	ND	ND
1,2,3-CB	2	ND	ND	ND
HCE	1	ND	ND	ND
2,4,5-TCT	1	ND	ND	ND
2,3,6-TCT	1	ND	ND	ND
1,2,4,5-CB	1	ND	ND	ND
1,2,3,5-CB	1	ND	ND	ND
1,2,3,4-CB	1	ND	ND	ND
Penta-CB	1	ND	ND	ND
Lipids (%)	-	0.90	0.92	1.10

*ND = none detected = < the detection limits shown.

Table 3
PAH Results - Water
Concentration µg/L (ppb)

Compounds	*MDL	#A1 01C	#A2 02C	#A3 03C
Napththalene	1.4	**ND	ND	ND
Acenaphthylene	0.6	ND	ND	ND
Acenaphthene	1.1	ND	ND	ND
Fluorene	0.7	ND	ND	ND
Phenanthrene	0.4	ND	ND	ND
Anthracene	0.3	ND	ND	ND
Fluoranthene	0.4	ND	ND	ND
Pyrene	0.4	ND	ND	ND
Benz[a]Anthracene	0.3	ND	ND	ND
Chrysene	0.3	ND	ND	ND
Benz[b]Fluoranthene	0.6	ND	ND	ND
Benz[k]Fluoranthene	0.6	ND	ND	ND
Benz[a]Pyrene	0.5	ND	ND	ND
Indeno[123-cd]Pyrene	1.1	ND	ND	ND
Dibenz[ah]Anthracene	1.1	ND	ND	ND
Benz[ghi]Perylene	0.7	ND	ND	ND

*MDL = Method Detection Level

** ND = none detected <MDL

Table 3
PAH Results - Water
Concentration µg/L (ppb)

Compounds	*MDL	A1	A2	A3
Napththalene	1.4	**ND	ND	ND
Acenaphthylene	0.6	ND	ND	ND
Acenaphthene	1.1	ND	ND	ND
Fluorene	0.7	ND	ND	ND
Phenanthrene	0.4	ND	ND	ND
Anthracene-d_{10}	% Rec.	86	108	108
Anthracene	0.3	ND	ND	ND
Fluoranthene	0.4	ND	ND	ND
Pyrene	0.4	ND	ND	ND
Benz[a]Anthracene	0.3	ND	ND	ND
Chrysene-d_{12}	% Rec.	99	82	89
Chrysene	0.3	ND	ND	ND
Benz[b]Fluoranthene	0.6	ND	ND	ND
Benz[k]Fluoranthene	0.6	ND	ND	ND
Benz[a]Pyrene	0.5	ND	ND	ND
Indeno[123-cd]Pyrene	1.1	ND	ND	ND
Dibenz[ah]Anthracene	1.1	ND	ND	ND
Benz[ghi]Perylene	0.7	ND	ND	ND

*MDL = Method Detection Level

** ND = none detected <MDL

Table 3
PAH Results - Water
Concentration µg/L (ppb)

Compounds	*MDL	A1	A2	A3
Napththalene	1.4	**ND	ND	ND
Acenaphthylene	0.6	ND	ND	ND
Acenaphthene	1.1	ND	ND	ND
Fluorene	0.7	ND	ND	ND
Phenanthrene	0.4	ND	ND	ND
Anthracene-d_{10}	% Rec.	52	48	43
Anthracene	0.3	ND	ND	ND
Fluoranthene	0.4	ND	ND	ND
Pyrene	0.4	ND	ND	ND
Benz[a]Anthracene	0.3	ND	ND	ND
Chrysene-d_{12}	% Rec.	97	85	84
Chrysene	0.3	ND	ND	ND
Benz[b]Fluoranthene	0.6	ND	ND	ND
Benz[k]Fluoranthene	0.6	ND	ND	ND
Benz[a]Pyrene	0.5	ND	ND	ND
Indeno[123-cd]Pyrene	1.1	ND	ND	ND
Dibenz[ah]Anthracene	1.1	ND	ND	ND
Benz[ghi]Perylene	0.7	ND	ND	ND

*MDL = Method Detection Level

** ND = none detected <MDL

Table 3A
PAH Results - Fish
Concentration ng/gm (ppb)

Compounds	*MDL	#A1 01D	#A2 02D	#A3 03D
Napththalene	95	**ND	103	ND
Acenaphthylene	26	ND	ND	ND
Acenaphthene	38	ND	ND	ND
Fluorene	82	ND	ND	ND
Phenanthrene	58	ND	88	ND
Anthracene-d_{10}	% Rec.	95	92	91
Anthracene	45	ND	ND	ND
Fluoranthene	49	ND	ND	ND
Pyrene	41	ND	ND	ND
Benz[a]Anthracene	26	ND	ND	ND
Chrysene-d_{12}	% Rec.	84	82	88
Chrysene	29	ND	ND	ND
Benz[b]Fluoranthene	33	ND	ND	ND
Benz[k]Fluoranthene	31	ND	ND	ND
Benz[a]Pyrene	41	ND	ND	ND
Indeno[123-cd]Pyrene	31	ND	ND	ND
Dibenz[ah]Anthracene	34	ND	ND	ND
Benz[ghi]Perylene	28	ND	ND	ND

*MDL= Method Detection Limit

**ND = none detected <MDL

Table 3A
PAH Results - Fish
Concentration ng/gm (ppb)

Compounds	*MDL	A1	A2	A3
Napththalene	95	**ND	108	ND
Acenaphthylene	26	ND	ND	ND
Acenaphthene	38	ND	ND	ND
Fluorene	82	ND	ND	ND
Phenanthrene	58	ND	ND	ND
Anthracene-d_{10}	% Rec.	98	71	114
Anthracene	45	ND	ND	ND
Fluoranthene	49	ND	ND	ND
Pyrene	41	ND	ND	ND
Benz[a]Anthracene	26	ND	ND	ND
Chrysene-d_{12}	% Rec.	98	68	100
Chrysene	29	ND	ND	ND
Benz[b]Fluoranthene	33	ND	ND	ND
Benz[k]Fluoranthene	31	ND	ND	ND
Benz[a]Pyrene	41	ND	ND	ND
Indeno[123-cd]Pyrene	31	ND	ND	ND
Dibenz[ah]Anthracene	34	ND	ND	ND
Benz[ghi]Perylene	28	ND	ND	ND

*MDL= Method Detection Limit

**ND = none detected <MDL

Table 3A
PAH Results - Fish
Concentration ng/gm (ppb)

Compounds	*MDL	A1	A2	A3
Napththalene	95	**ND	108	ND
Acenaphthylene	26	ND	ND	ND
Acenaphthene	38	ND	ND	ND
Fluorene	82	ND	ND	ND
Phenanthrene	58	ND	ND	ND
Anthracene-d_{10}	% Rec.	55	31	118
Anthracene	45	ND	ND	ND
Fluoranthene	49	ND	ND	ND
Pyrene	41	ND	ND	ND
Benz[a]Anthracene	26	ND	ND	ND
Chrysene-d_{12}	% Rec.	72	28	109
Chrysene	29	ND	ND	ND
Benz[b]Fluoranthene	33	ND	ND	ND
Benz[k]Fluoranthene	31	ND	ND	ND
Benz[a]Pyrene	41	ND	ND	ND
Indeno[123-cd]Pyrene	31	ND	ND	ND
Dibenz[ah]Anthracene	34	ND	ND	ND
Benz[ghi]Perylene	28	ND	ND	ND

*MDL= Method Detection Limit

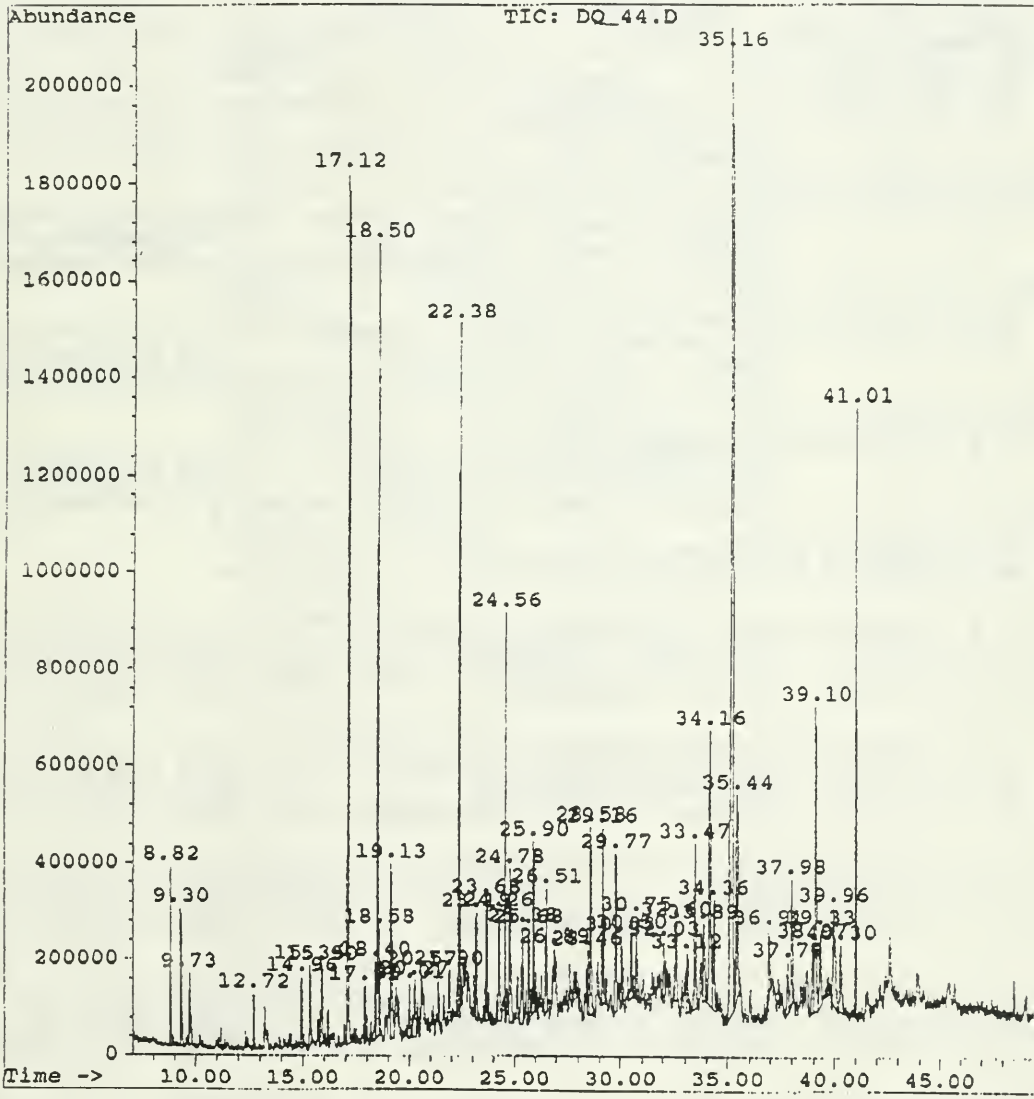
**ND = none detected <MDL

APPENDIX III

Results of GC-MSD full scan analysis and library search by Ortech International on Deep/Quest 2 tire leaching study.

The following is a preliminary scan of the Day 30 Cut Tire (A3) water sample run by Ortech International at the request of Deep/Quest 2 Underseas Research Society Inc., in an attempt to isolate the possible toxic factor present in the experimental samples. The number of peaks recorded and the poor quality of most of the matches (less than 70% is not considered to be very reliable) makes identification of the unknown agent impossible at this time. Dr. Gordon Thomas (Manager of Organic Analysis, Ortech International) reviewed this data and ticked the compound that he feels is the most likely candidate for each peak. Clearly further investigation is required if the nature of the toxic factor(s) is to be determined.

File: D:\DATA\DQ\DQ_44.D
Operator: JUDITH
Date Acquired: 11 Jul 91 4:05 pm
Method File: MOEPAH1.M
Sample Name: DEEPQUEST WATER CHOPPED TIRES
Misc Info: 2 uL (+400) ALS SIM
ALS vial: 5



```
Information from Data File:
     File:           D:\DATA\DQ\DQ_44.D
     Operator:       JUDITH
     Date Acquired:  11 Jul 91    4:05 pm
     Method File:    MOEPAH1.M
     Sample Name:                        DEEPQUEST  WATER  CHOPPED TIRES
     Misc Info:                          2 uL   (+400)   ALS   SIM
     Vial Number:    5

Search Libraries:    D:\DATABASE\NBS49K.L               Minimum Quality:   0

Unknown Spectrum:    Apex minus start of peak
Integration Events:  EVENTS.E

Pk#  RT    Area%            Library/ID                     Ref#      CAS#    Qual
_________________________________________________________________________________

  1   8.82  0.27 D:\DATABASE\NBS49K.L
                 No matches found

  2   9.30  1.37 D:\DATABASE\NBS49K.L
                 Phosphoric acid, triethyl ester          14943 000078-40-0 64✓
                 Phosphoric acid, diethyl ester            8949 000598-02-7 50
                 Phosphoric acid, diethyl pentyl es       22964 020195-08-8 38

  3   9.73  0.86 D:\DATABASE\NBS49K.L
                 2-Pentanamine, N-ethyl-4-methyl-          4547 042966-64-3 37✓
                 Ether, 1-butylvinyl methyl                2705 016519-66-7 32
                 Phenol, 4-(2-aminopropyl)-, (.+-.)        8469 001518-86-1 25

  4  12.72  0.54 D:\DATABASE\NBS49K.L
                 Benzaldehyde, 2,4,6-trimethyl-            7892 000487-68-3 72 -
                 Benzo[b]thiophene, 5-methyl-              7880 014315-14-1 62✓
                 Benzo[b]thiophene, 4-methyl-              7879 014315-11-8 62

  5  14.96  0.57 D:\DATABASE\NBS49K.L
                 No matches found

  6  15.35  0.83 D:\DATABASE\NBS49K.L
                 Formamide, N-phenyl-                      3329 000103-70-8 81
                 2,4,6-Cycloheptatrien-1-one, 2-ami        3333 006264-93-3 74 ?
                 Aniline (ACN)(8CI)                         897 000062-53-3 46

  7  15.90  0.94 D:\DATABASE\NBS49K.L
                 Pyridine, 3-butyl-, 1-oxide               8490 031396-33-5 45✓
                 Camphorsulfonic acid                     24298 003144-16-9 39
                 1-Piperidinecarboxaldehyde, 2-(3,4       14647 052196-11-9 27

  8  17.12  6.84 D:\DATABASE\NBS49K.L
                 Phenol, (1,1-dimethylethyl)-4-meth       14670 025013-16-5 62✓
                 9H-Fluorene, 4-methyl-                   14769 001556-99-6 58
                 9H-Fluorene, 2-methyl-                   14779 001430-97-3 52

  9  17.91  0.46 D:\DATABASE\NBS49K.L
                 1,3-Benzenediamine, 4-methoxy-            5873 000615-05-4 27✓
                 Phenol, 2-methoxy-4-methyl-               5891 000093-51-6 27
                 Benzene, 1,4-dimethoxy-2,3,5,6-tet       17422 013199-54-7 25
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Pk#  RT    Area%            Library/ID                     Ref#      CAS#    Qual
---------------------------------------------------------------------------------
 10  18.40  0.80 D:\DATABASE\NBS49K.L
                 1-Piperidinamine                           1336 002213-43-6 25
                 Cholestan-3-one, 4,4-dimethyl-, cy        45439 054498-64-5 25  ?
                 Phosphoric acid, diethyl pentyl es        22964 020195-08-8 23

 11  18.50  6.58 D:\DATABASE\NBS49K.L
                 Ethanol, 2-[(1-methylethyl)amino]-         1635 000109-56-8 28 ✓
                 Urea, tetramethyl-                         2829 000632-22-4 23
                 Propiomazine (USAN)                       38029 000362-29-8 23

 12  18.58  0.93 D:\DATABASE\NBS49K.L
                 Thiophene, 2-butyl-5-(2-methylprop        17883 054845-35-1 40✓
                 Thiophene, 2,5-dibutyl-                   17886 006911-45-1 40
                 1-Propanone, 1-(2,4,6-trihydroxyph        14997 002295-58-1 40

 13  19.13  2.51 D:\DATABASE\NBS49K.L
                 Rhodium, tris[(1,2,3-.eta.)-2-meth        29678 074811-17-9 28
                 Quinoline, 2,6-dimethyl-                   9870 000877-43-0 22✓
                 Acridine, 9-chloro-                       21089 001207-69-8 14

 14  20.01  0.68 D:\DATABASE\NBS49K.L
                 Hydrazine, 1,1-diphenyl-2-(2,4,6-t        42179 001707-75-1 72✓
                 Benzenamine, N-phenyl-                    12483 000122-39-4 58
                 [1,1'-Biphenyl]-2-amine                   12484 000090-41-5 58

 15  20.27  1.04 D:\DATABASE\NBS49K.L
                 1,3-Benzodioxole, 5-(1,1-dimethyle        14260 007228-36-6 49✓
                 2-Cyclopenten-1-one, 4-hydroxy-3-m        14271 000487-67-2 38
                 Tricyclo[3.3.1.13,7]decane-1-carbo        32262 075112-78-6 35

 16  20.57  0.40 D:\DATABASE\NBS49K.L
                 Benzofuran, 2-methyl-                      5028 004265-25-2 80✓
                 Benzofuran, 7-methyl-                      5033 017059-52-8 72
                 Benzaldehyde, ethenyl-                     5030 043145-54-6 56

 17  21.90  0.67 D:\DATABASE\NBS49K.L
                 1,4,5,6-TETRAMETHYL-2-PYRIMIDONE           8614 078365-50-1 11
                 2-METHYL-1-ETHYLPYRROLIDINE                2472 000765-79-7 11  ?
                 Silacyclopent-3-ene, 3-methyl-             1113 054077-65-5 11

 18  22.38  6.03 D:\DATABASE\NBS49K.L
                 1,1,3,3-TETRAMETHYL-1,3-DISILAINDA        19747 054113-93-8 50
                 Oxirane, [[4-(1,1-dimethylethyl)ph        19803 003101-60-8 27  ?
                 Benzene, 1-methyl-3-(methylthio)-          5914 004886-77-5 14

 19  23.19  0.99 D:\DATABASE\NBS49K.L
                 Triallate                                 34229 002303-17-5 64
                 Acetamide, N,N-dibutyl-                   12889 001563-90-2 32  ?
                 1-Pentanamine, N-methyl-N-(1-methy         6952 005756-49-0 17

 20  23.68  1.22 D:\DATABASE\NBS49K.L
                 Ethanol, 2-chloro-, phosphate (3:1        31768 000115-96-8 36 ✓
                 Ethanol, 2-chloro-, phosphite (3:1        29639 000140-08-9 28
                 Propane, 1,1,2-trichloro-                  7385 000598-77-6 12
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Pk#  RT    Area%               Library/ID                   Ref#      CAS#    Qual
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 21  24.26  1.40 D:\DATABASE\NBS49K.L
                 1,1-DIMETHYL-1-SILAACENAPHTHENE             18339 028871-17-2 74
                 Naphthalene, 1,6-dimethyl-4-(1-met          18392 000483-78-3 49 ✓
                 Azulene, 1,4-dimethyl-7-(1-methyle          18391 000489-84-9 32

 22  24.56  0.65 D:\DATABASE\NBS49K.L
                 2,4(1H,3H)-Pyrimidinedione, 5-nitr           9773 000611-08-5 36 ?

 23  24.78  1.91 D:\DATABASE\NBS49K.L
                 2-Hexanamine, 5-methyl-                      2778 028292-43-5 25 ✓
                 2-Propen-1-amine, 2-bromo-N-methyl           7975 028952-70-7 23
                 Benzeneethanamine, 4-chloro-.alpha          12431 000064-12-0 17

 24  25.38  1.26 D:\DATABASE\NBS49K.L
                 Bicyclo[2.2.2]oct-2-ene, 1,4,5,5,6          23674 031463-42-0 25
                 Furan, 2-methyl-5-(methylthio)-              4220 013678-59-6 22 ✓
                 1,3-Cyclopentanedione, 4-hydroxy-2           4224 004800-04-8 16

 25  25.68  1.01 D:\DATABASE\NBS49K.L
                 Acridine, 9,10-dihydro-9,9-dimethy          20373 006267-02-3 97 ✓
                 9(10H)-Anthracenone                         17479 000090-44-8 64
                 Benzenamine, N,N'-methanetetraylbi          17437 000622-16-2 59

 26  25.90  1.46 D:\DATABASE\NBS49K.L
                 1,2-Benzenedicarboxylic acid, buty          34371 000084-64-0 64 ✓
                 1,2-Benzenedicarboxylic acid, dihe          39927 003648-21-3 53
                 1,2-Benzenedicarboxylic acid, buty          39920 000089-18-9 50

 27  26.51  1.21 D:\DATABASE\NBS49K.L
                 Acetaldehyde, (1-methylethyl)hydra           1339 007422-89-1 14
                 2,4-Heptanedione                             4253 007307-02-0 11  ?
                 Benzo[3,4]cyclobuta[1,2-d]-1,3-dio          14246 063456-12-2 10

 28  26.89  0.20 D:\DATABASE\NBS49K.L
                 Acetamide, N-phenyl-                         5377 000103-84-4 50 ✓

 29  28.46  0.59 D:\DATABASE\NBS49K.L
                 Thiourea, N-ethyl-N,N'-diphenyl-            28055 015093-51-3 35
                 Thiourea, N-phenyl-N'-(1-phenyleth          28057 015093-41-1 35  ?
                 Chrysene, 5-ethyl-                          28131 054986-62-8 35

 30  28.58  2.29 D:\DATABASE\NBS49K.L
                 Urea, N,N'-dicyclohexyl-                    23055 002387-23-7 53 ✓
                 2H-Pyran-2-one, tetrahydro-4,4,6-t           6706 010603-06-2 25
                 Cyclopropane, 1-methyl-2-(1-methyl           6415 062238-06-6 17

 31  29.16  1.63 D:\DATABASE\NBS49K.L
                 Furan, 2-methoxy-                            1093 025414-22-6 30
                 3-Pentenoic acid, 2,2-dimethyl-              4302 016642-52-7 25  ?
                 1,3-Cyclohexanedione, 2-methyl-              3898 001193-55-1 22

 32  29.77  1.65 D:\DATABASE\NBS49K.L
                 6H-Purin-6-one, 1,7-dihydro-1-meth           8123 001125-39-9 59
                 2-Benzothiazolamine, N-cyclohexyl-          24364 028291-75-0 46 ✓
                 Benzoyl chloride, 3-nitro-                  15686 000121-90-4 42
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Pk#  RT    Area%              Library/ID                  Ref#     CAS#    Qual

 33  30.03  0.70 D:\DATABASE\NBS49K.L
                 1H-Benz[de]isoquinoline-1,3(2H)-di   18035 000081-83-4 43 ✓
                 Benzenamine, 4-methyl-2,6-dinitro-   17979 006393-42-6 35
                 9H-Xanthen-9-ol, 9-phenyl-           30612 000596-38-3 23

 34  30.50  0.66 D:\DATABASE\NBS49K.L
                 Quinazoline, 4-(1-methylethyl)-, 1   16302 050915-32-7 15
                 5-Decene-3,7-diyne, 5,6-diethyl-     16368 061228-08-8 11   ?
                 Stannane, (2,6-dimethylphenyl)trim   29962 019962-41-5 10

 35  30.75  0.82 D:\DATABASE\NBS49K.L
                 3-Dibenzofuranamine                  15290 004106-66-5 11
                 Quinazoline, 4-(1-methylethyl)-, 1   16302 050915-32-7 10   ?
                 1(2H)-Naphthalenone, 3,4-dihydro-4   16346 010468-61-8 10

 36  32.03  0.60 D:\DATABASE\NBS49K.L
                 Benzyl butyl phthalate               35198 000085-68-7 64 ✓
                 1,2-Benzenedicarboxylic acid, mono   31080 004376-20-9 38
                 Carbamodithioic acid, acetyl-, met    7973 016696-88-1 38 ?

 37  32.60  0.96 D:\DATABASE\NBS49K.L
                 Oxazole, 2-methyl-4,5-diphenyl-      24811 014224-99-8 14
                 Pyridine, 3,4-bis(p-methoxyphenyl)   32821 015638-13-8 12   ?
                 Indole, 2-(2-toluoyl)-               24813 001026-19-3 10

 38  33.12  0.72 D:\DATABASE\NBS49K.L
                 Hexadecane, 1-iodo-                  39049 000544-77-4 10
                 1,2,3-Thiadiazolium, 3-(2-chloro-5   23299 032864-80-5 10   ?
                 Thiophene, 2-ethyl-5-propyl-          9111 054244-74-5 10

  9  33.47  2.17 D:\DATABASE\NBS49K.L
                 3-Buten-2-one, 4-(2,2-dimethyl-1-a    6116 050838-17-0 17   ?
                 1H-1,2,4-Triazole, 3-ethyl-           1049 007411-16-7 12

 40  33.89  1.23 D:\DATABASE\NBS49K.L
                 1H-Naphtho[2,1-b]pyran-1-one, 6-me   25646 005891-93-0 72
                 [1]Benzothieno[3,2-b][1]benzothiop   25601 000248-70-4 53 ✓
                 [1,1'-Biphenyl]-4,4'-diamine, 3,3'   25687 054827-17-7 50

 41  34.16  4.68 D:\DATABASE\NBS49K.L
                 Naphtho[1,2-b]furan-4,5-dione, 2-m   20905 017112-93-5 45 ✓
                 Benzene, (ethenyloxy)phenoxy-        20969 055030-71-2 38
                 9H-Xanthen-9-one, 4-hydroxy-         20907 014686-63-6 28

 42  34.36  1.48 D:\DATABASE\NBS49K.L
                 Butanamide, 2-(dimethylamino)-N-[7   48177 018397-13-2 14
                 2,1,3-Benzoselenadiazole             15331 000273-15-4 12   ?
                 4(3H)-Quinazolinone, 3-(2-propynyl   15475 016347-56-1 12

 43  35.16 19.92 D:\DATABASE\NBS49K.L
                 Cyclopentanecarboxamide, 3-ethyl-2   24224 074793-56-9 23 ✓

 44  35.44  3.10 D:\DATABASE\NBS49K.L
                 Thiazolo[5,4-d]pyrimidine, 5-amino   23293 019844-40-7 50
                 2,2'-Bipyridine, 4,4'-dimethyl-      15525 001134-35-6 46 ✓
                 2,2 -BIS-(5-METHYLPYRIDYL)           15526 001762-34-1 43
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Pk#  RT     Area%              Library/ID                    Ref#      CAS#    Qual

 45  36.91  0.75 D:\DATABASE\NBS49K.L
                 N,N-DIMETHYL-2,2-DIPHENYL-2-PHENYL    38463 072572-06-6 36
                 Benzaldehyde, 3-[4-(1,1-dimethylet    27777 069770-23-6 25  ?
                 Indolo[2,3-b]quinolizine, 1,2,3,4,    25686 013233-45-9 16

 46  37.79  0.58 D:\DATABASE\NBS49K.L
                 No matches found

 47  37.98  1.59 D:\DATABASE\NBS49K.L
                 1,3-Cyclohexadiene-1-carboxylic ac    30305 040801-43-2 25
                 Harmine                               20919 000442-51-3 25
                 [1,1'-Biphenyl]-4,4'-diamine, 3,3'    20985 000119-93-7 22 ✓

 48  38.97  1.03 D:\DATABASE\NBS49K.L
                 1,4-Benzenediamine, N-phenyl-         15535 000101-54-2 76 ✓
                 Benzidine (8CI)                       15537 000092-87-5 68
                 2,2'-Bipyridine, 4,4'-dimethyl-       15525 001134-35-6 58

 49  39.10  3.84 D:\DATABASE\NBS49K.L
                 3,7,11-Tridecatrienenitrile, 4,8,1    24235 006006-01-5 56 ✓
                 1,5-Heptadiene, 3,3,6-trimethyl-       6058 035387-63-4 50
                 2,6,10-Dodecatrien-1-ol, 3,7,11-tr    22744 004602-84-0 45

 50  39.33  1.19 D:\DATABASE\NBS49K.L
                 4-AMINO-3-(N,N-DIMETHYLAMINO)-9-BE    35584 094127-28-3 32
                 2,4,7-Trinitrofluorenone              35536 000129-79-3 25
                 D-Homo-24-nor-17-oxachola-1,20,22-    44556 013072-74-7 23

 51  39.96  2.11 D:\DATABASE\NBS49K.L
                 Estra-1,3,5(10)-trien-17-one, 3-hy    33676 001094-07-1
                 Ferrocene, 1,1'-bis(1-oxopropyl)-     33570 001274-01-7
                 1H-Benz[de]isoquinoline-1,3(2H)-di    25776 003271-05-4

 52  40.30  1.18 D:\DATABASE\NBS49K.L
                 4H-1-Benzopyran-2-carboxylic acid,    31195 005823-37-0 17
                 Dibenz[a,j]acridine                   31245 000224-42-0 17  ?
                 Silane, 1,3,5-benzenetriyltris[tri    33077 005624-60-2  8

 53  41.01  0.91 D:\DATABASE\NBS49K.L
                 Epinephrine                           15255 000051-43-4 38
                 Acetic acid, [(aminocarbonyl)amino     4888 000585-05-7 36
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